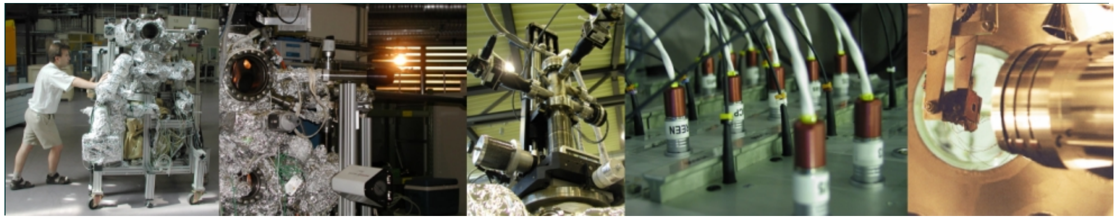


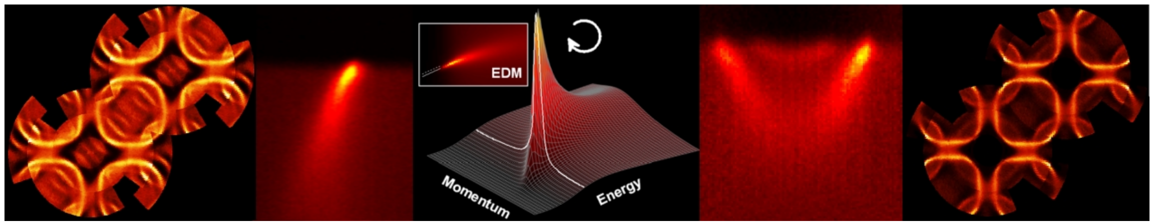
How to undress a quasiparticle?

Tutorial

Sergey V. Borisenko

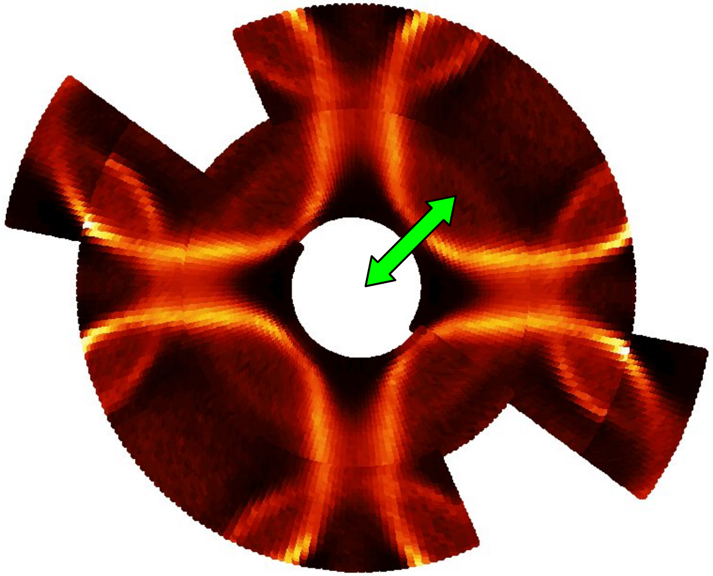
Leibniz-Institute
for Solid State and
Materials Research
Dresden

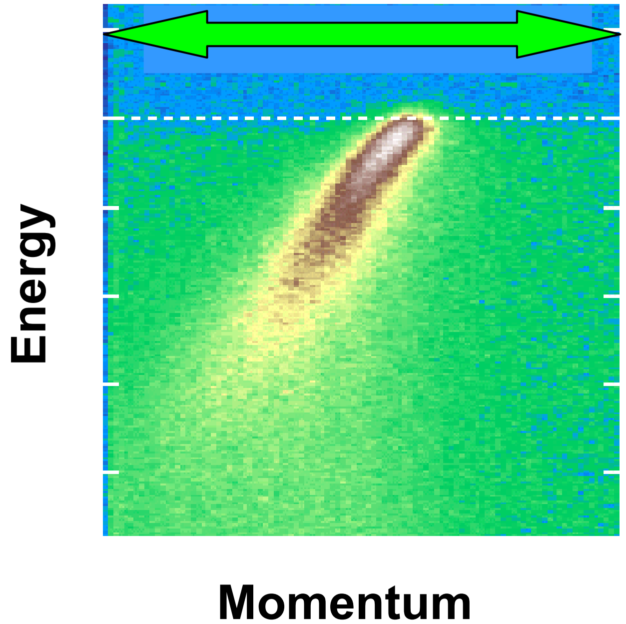
Jaszowiec, June 4-5, 2005
Pre-School "Old and new quasiparticles"

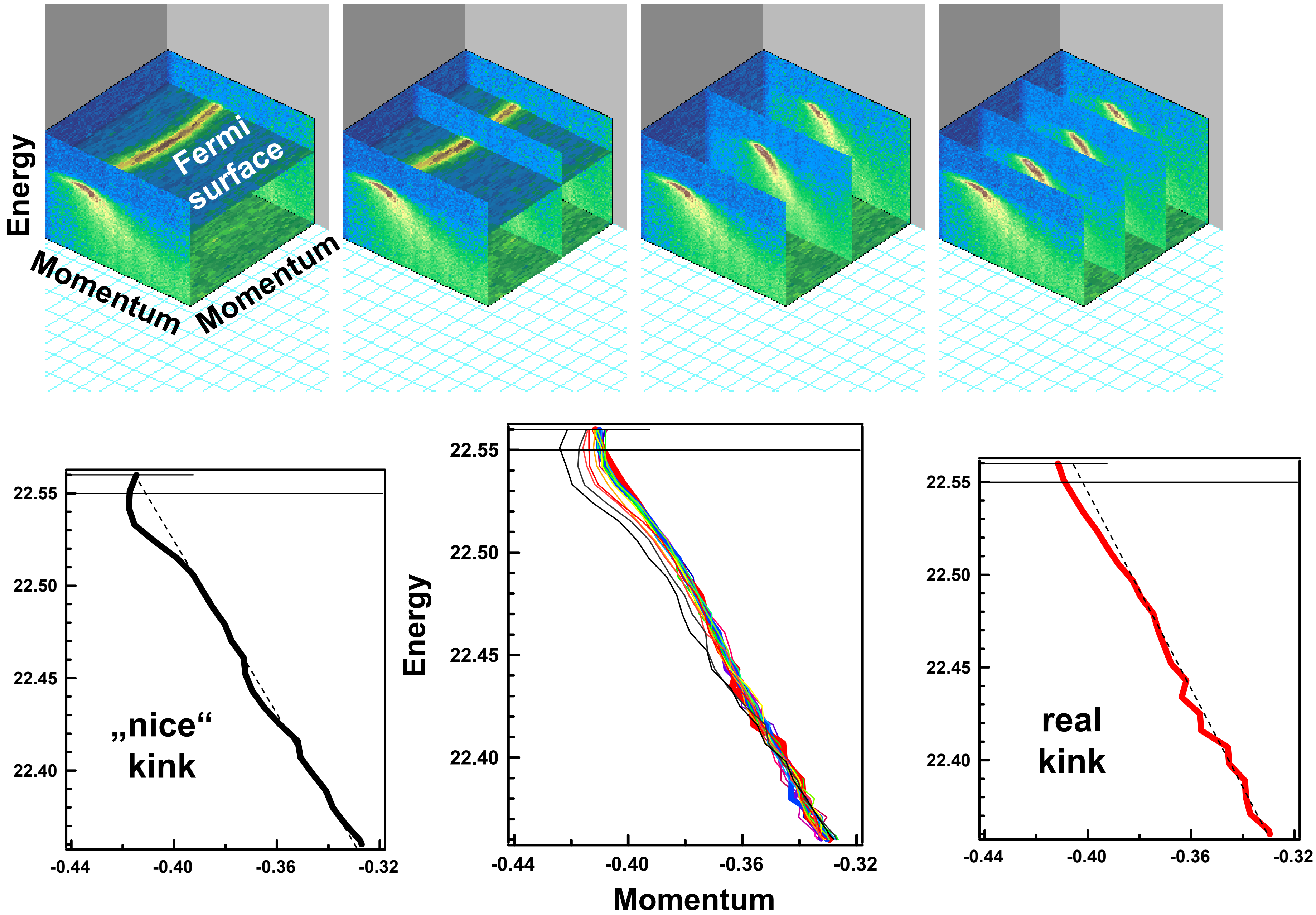


Nodal direction (GX)

No gap, simple bare dispersion.

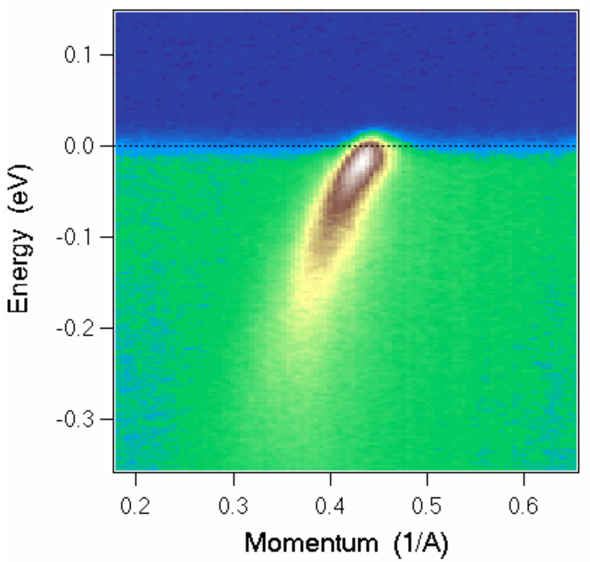


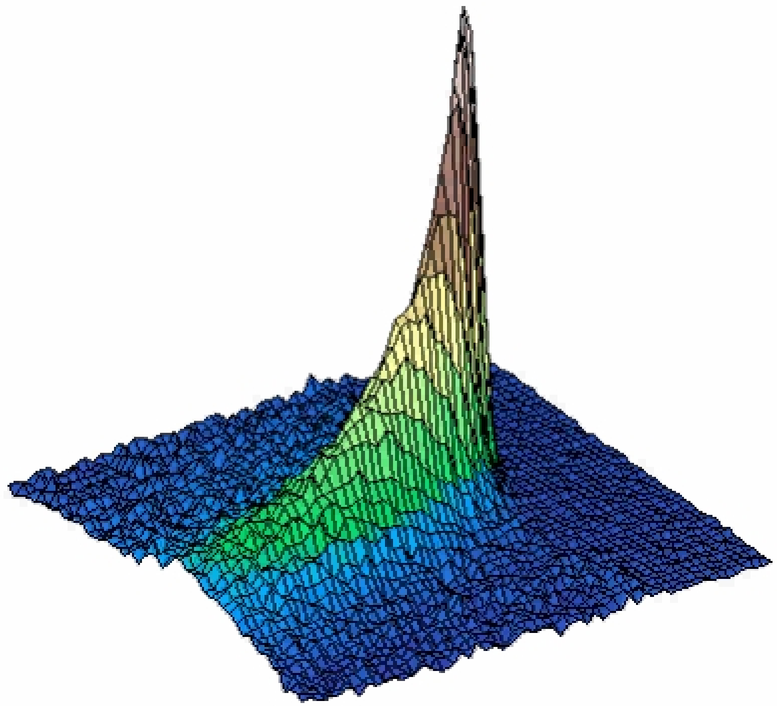


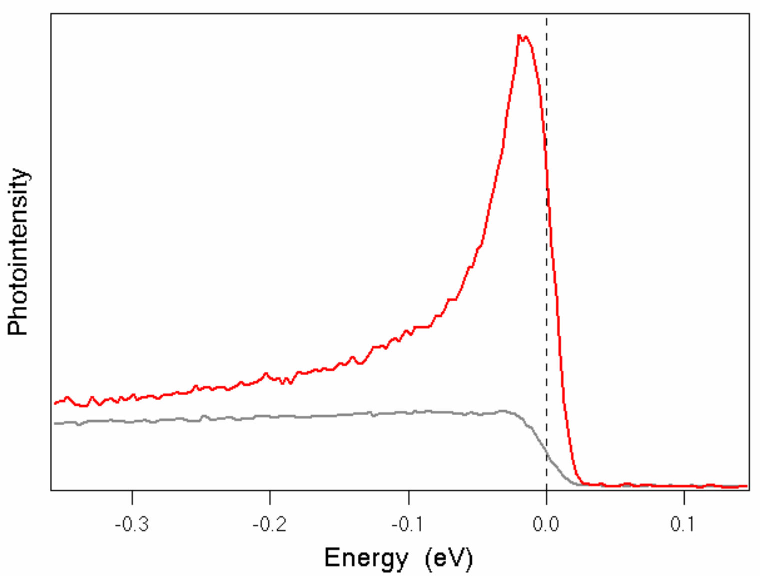


Energy
Momentum
Momentum
Fermi surface
„nice“ kink
real kink
Energy
Momentum
22.55
22.50
22.45
22.40
-0.44
-0.40
-0.36
-0.32

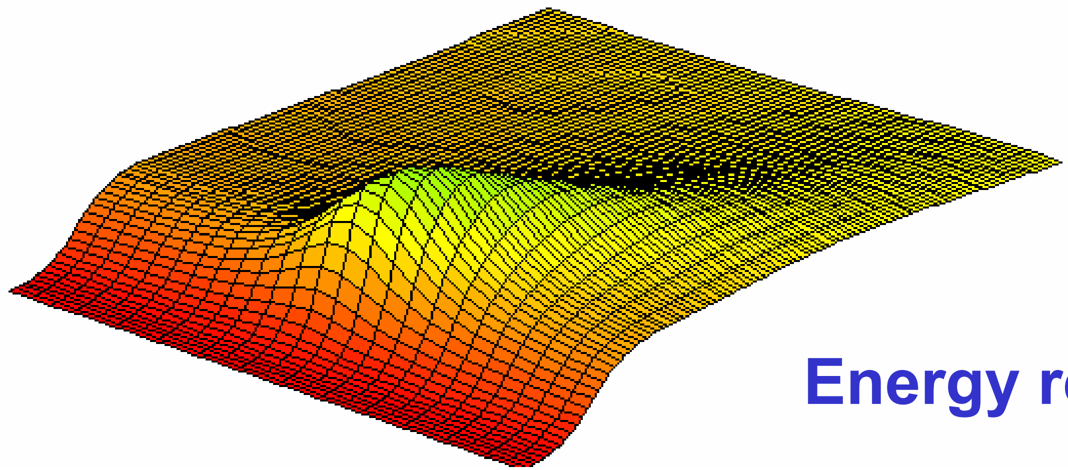
Extrinsic background







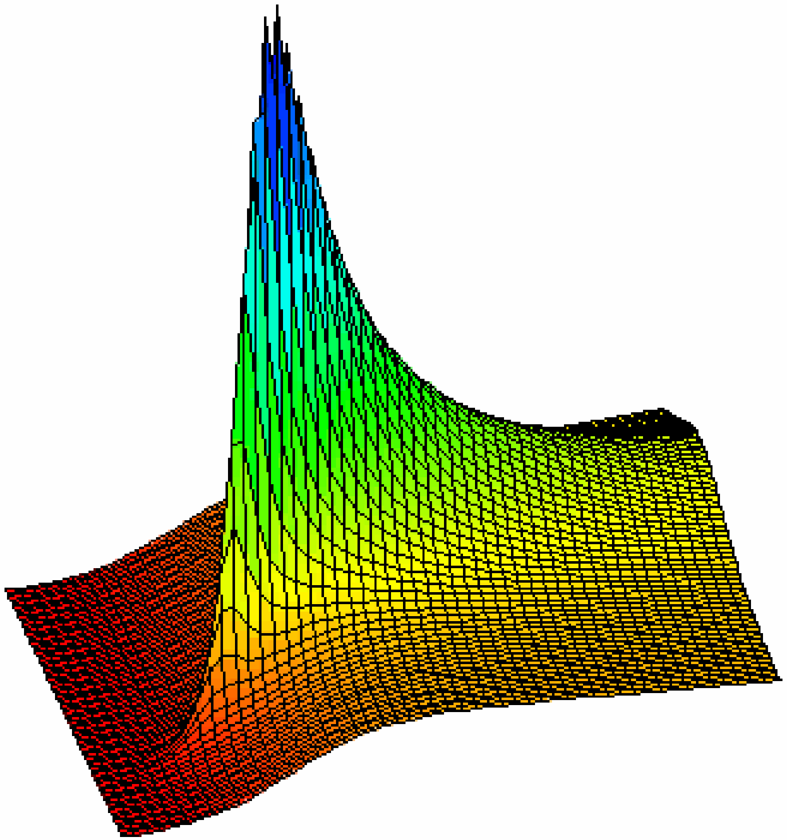
Last century ARPES



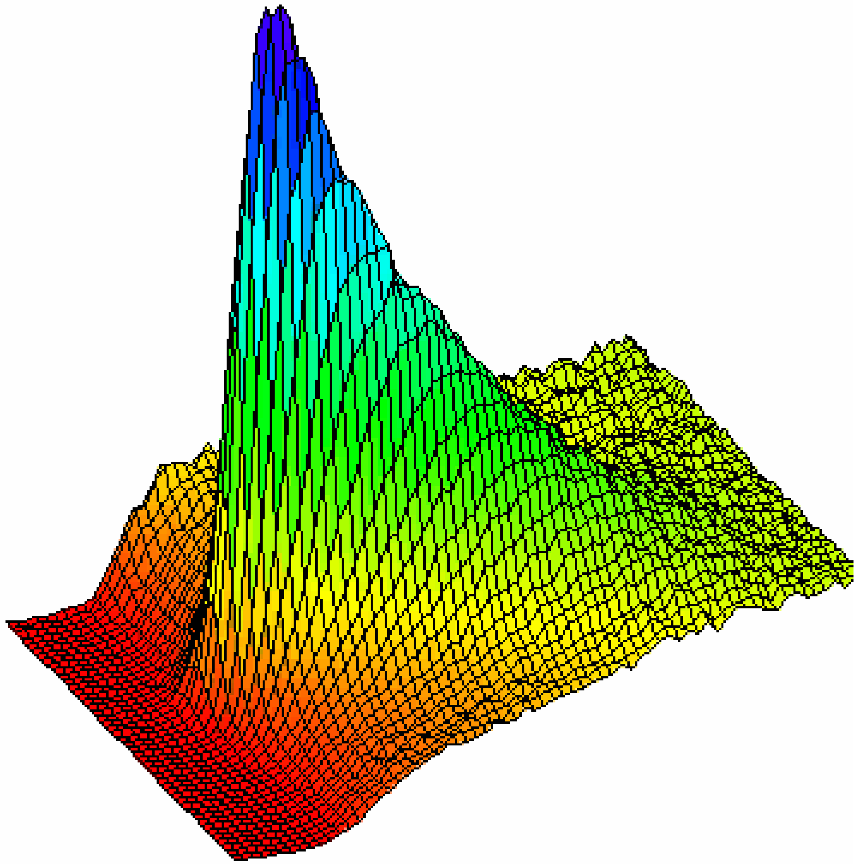
Energy resolution = 5meV

Angular resolution = 2º

What is possible now



Simulation

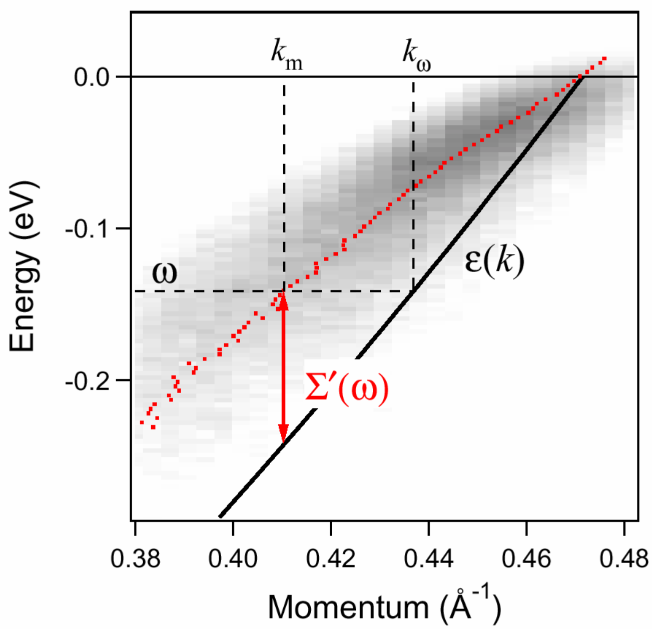


Experiment

Angular resolution = 0.2º

Self-energy approach

$$A(\omega, \mathbf{k}) = -\frac{1}{\pi} \frac{\Sigma''(\omega)}{(\omega - \varepsilon(\mathbf{k}) - \Sigma'(\omega))^2 + \Sigma''(\omega)^2}$$



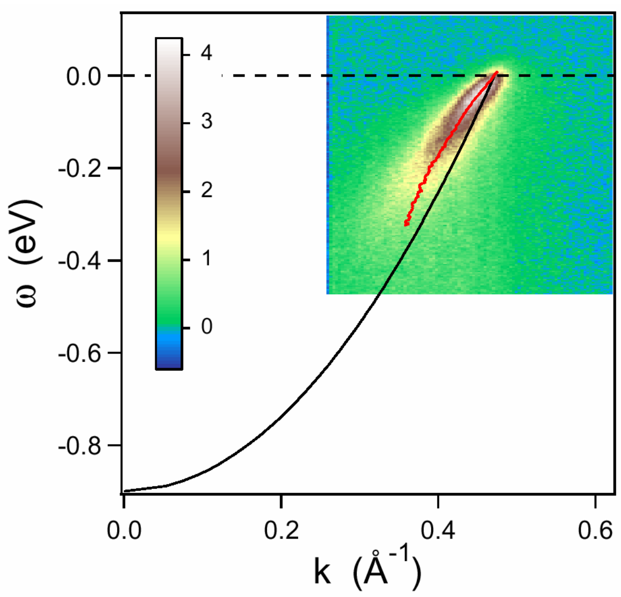
$$\Sigma'(\omega) = \omega - \varepsilon(k_m)$$

$$\Sigma''(\omega) = -v_F W(\omega)$$

Self-energy approach: fitting procedure

$$\Sigma'(\omega) = \frac{v_F}{2}(k_m^2(\omega) - k_F^2) + \omega,$$

$$\Sigma''(\omega) = -v_F W(\omega)\sqrt{k_m^2(\omega) - W^2(\omega)}.$$



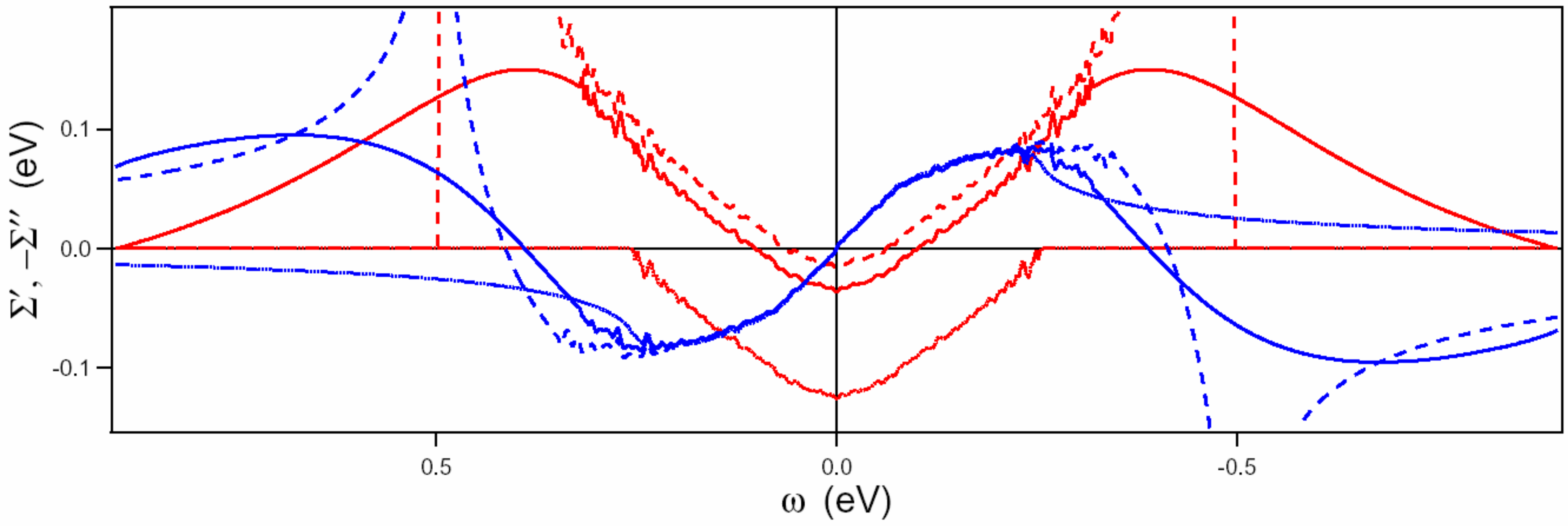
$$\Sigma'(\omega) = \mathrm{KK}\ \Sigma''(\omega)$$

Three parameters

bare band parameter: v_F or ω_0

tail parameters: ω_c and n

Kramers-Kronig transform $\Sigma'(\omega) = \mathrm{KK}\ \Sigma''(\omega)$



$$\Sigma''(\omega) = -\begin{cases} \alpha\omega^2 + C & \text{for } |\omega| < \omega_c, \\ 0 & \text{for } |\omega| > \omega_c, \end{cases}$$

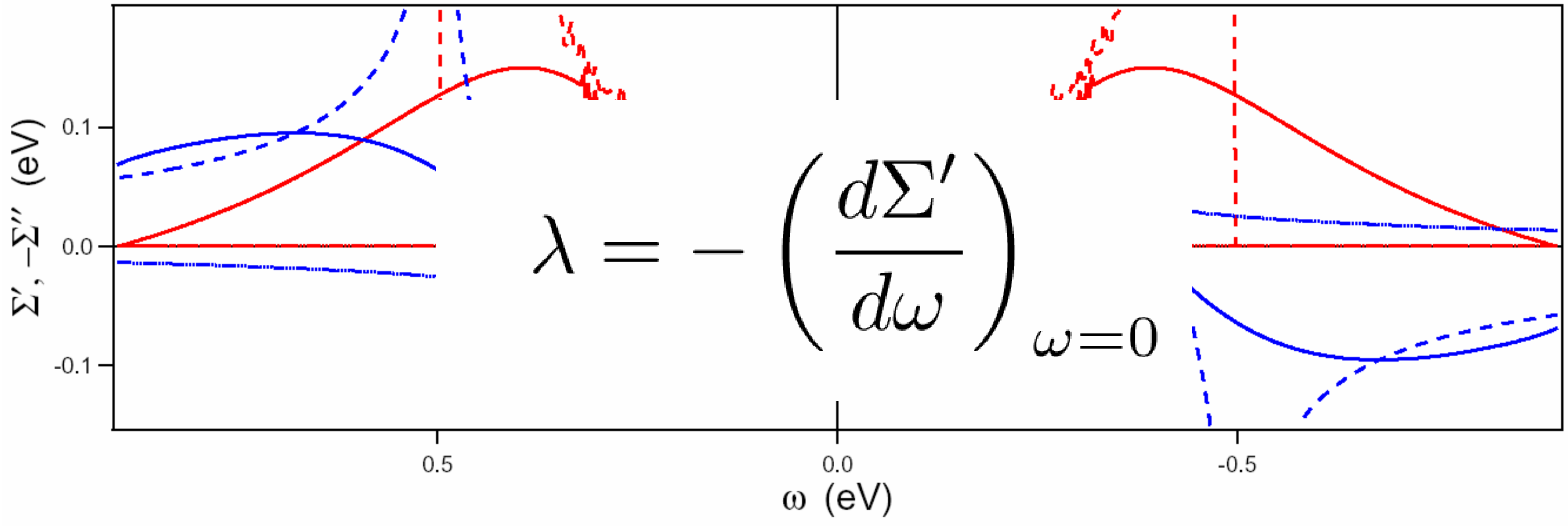
$$\Sigma''(\omega) = -\begin{cases} \alpha\omega^2 + C & \text{for } |\omega| < \omega_c, \\ \alpha\omega_c^2 + C & \text{for } |\omega| > \omega_c, \end{cases}$$

$$\lambda = \frac{2}{\pi}\left(\alpha\,\omega_c - \frac{C}{\omega_c}\right) \approx \frac{2}{\pi}\,\alpha\,\omega_c$$

$$\lambda = 4\,\alpha\,\omega_c/\pi$$

Kramers-Kronig transform

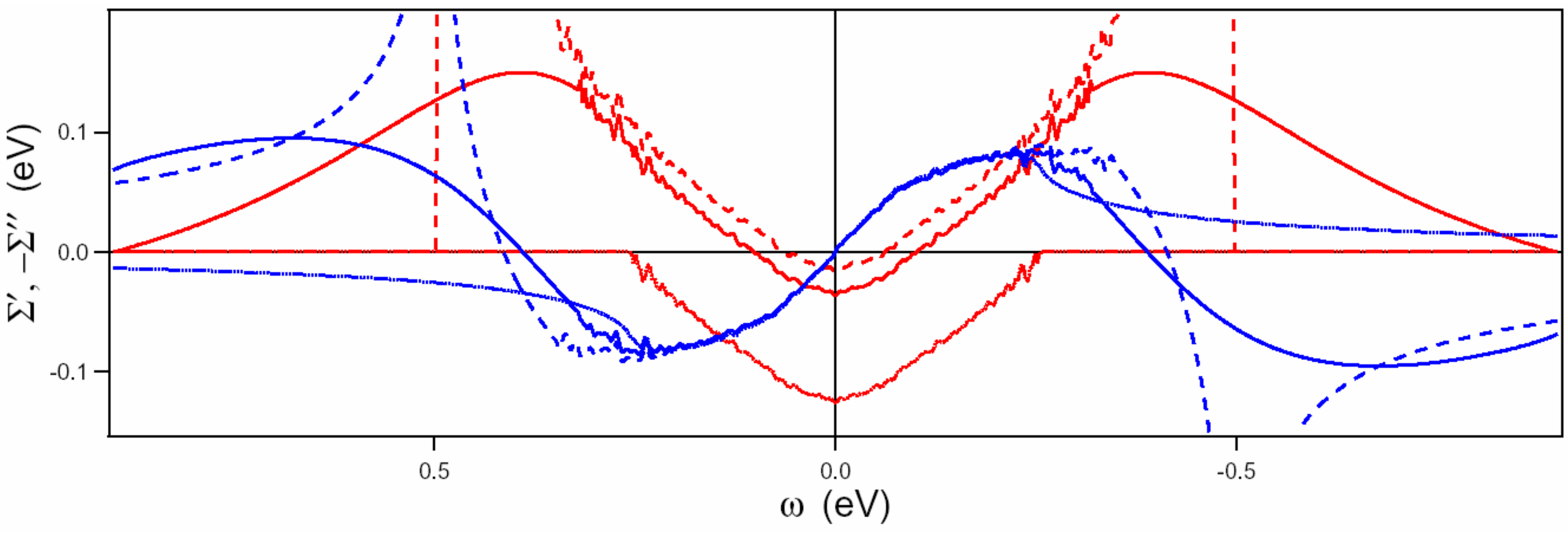
$$\Sigma'(\omega) = \mathrm{KK}\ \Sigma''(\omega)$$



$$\lambda = -\left(\frac{d\Sigma'}{d\omega}\right)_{\omega=0}$$

$$\lambda = \frac{-2}{\pi}\int_0^\infty \frac{\Sigma''(\omega) - \Sigma''(0)}{\omega^2}\, d\omega$$

Kramers-Kronig transform $\Sigma'(\omega) = \mathrm{KK}\,\Sigma''(\omega)$



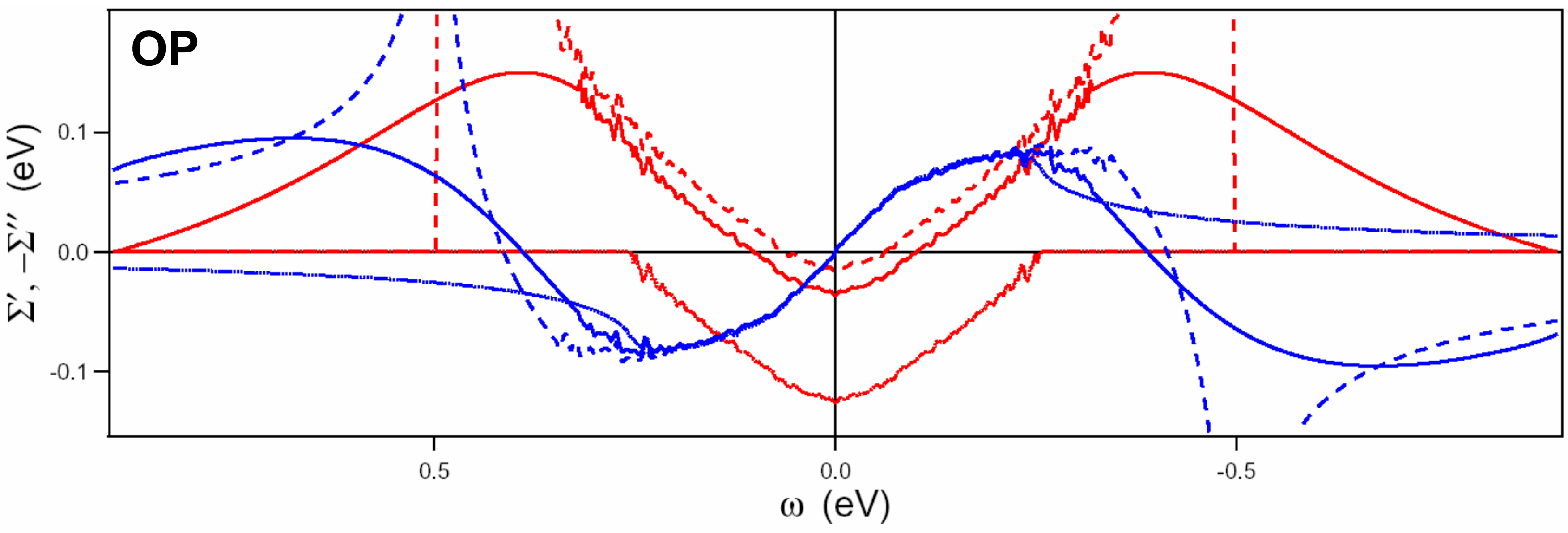
$$\Sigma''(\omega) = \begin{cases} \Sigma''_{width}(|\omega|) & \text{for } |\omega| < \omega_m, \\ \Sigma''_{mod}(\omega) & \text{for } |\omega| > \omega_m, \end{cases}$$

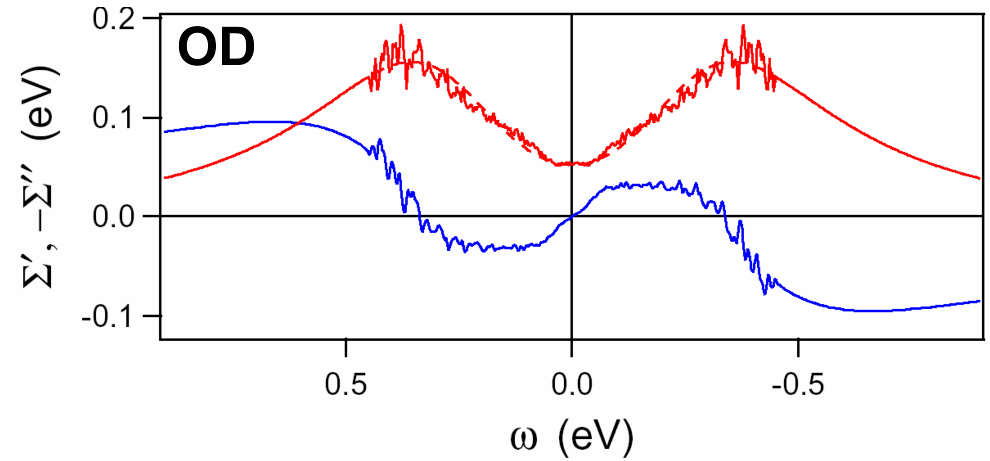
$$\Sigma''_{mod}(\omega) = -\frac{\alpha\,\omega^2 + C}{1 + \left|\frac{\omega}{\omega_c}\right|^n},$$

Kordyuk *PRB* 2005

Kramers-Kronig transform

$\Sigma'(\omega) = \mathrm{KK}\ \Sigma''(\omega)$





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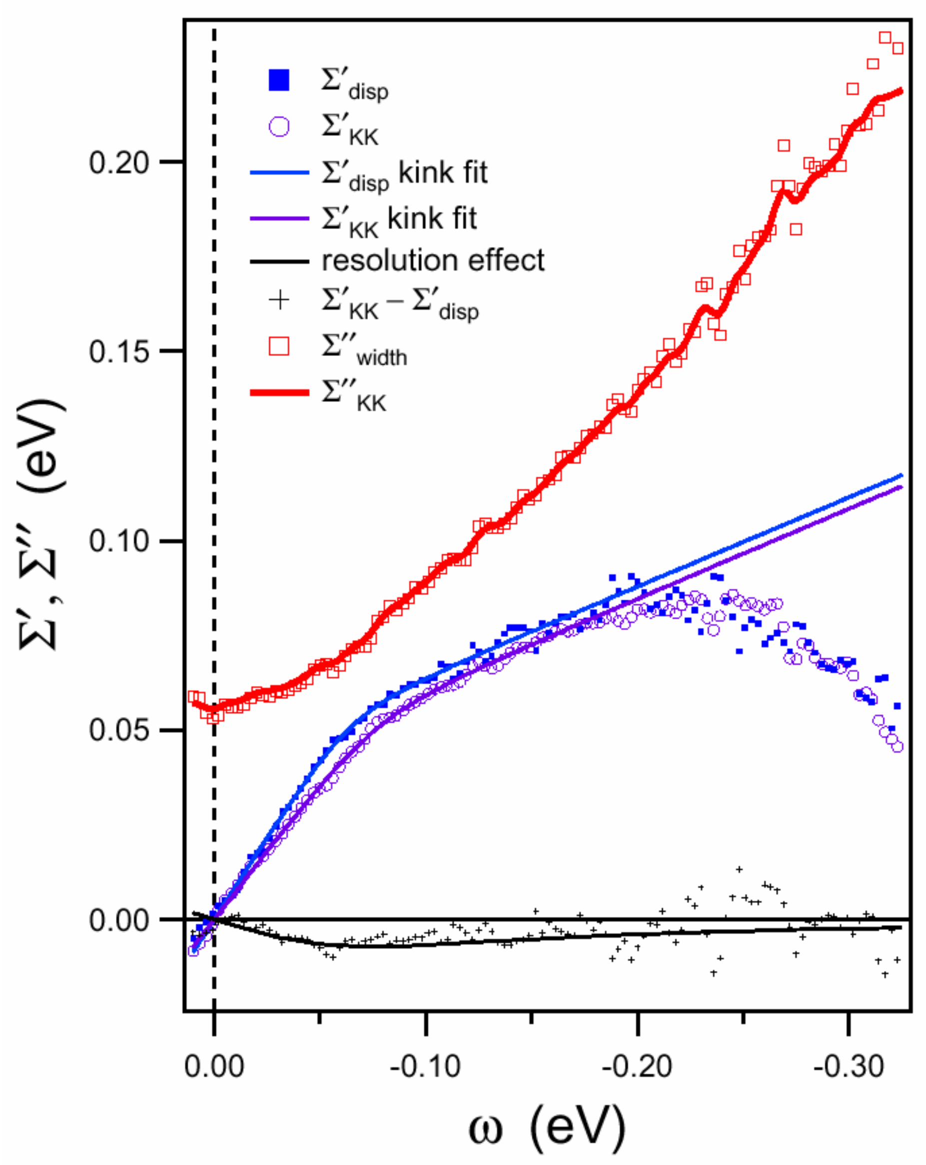
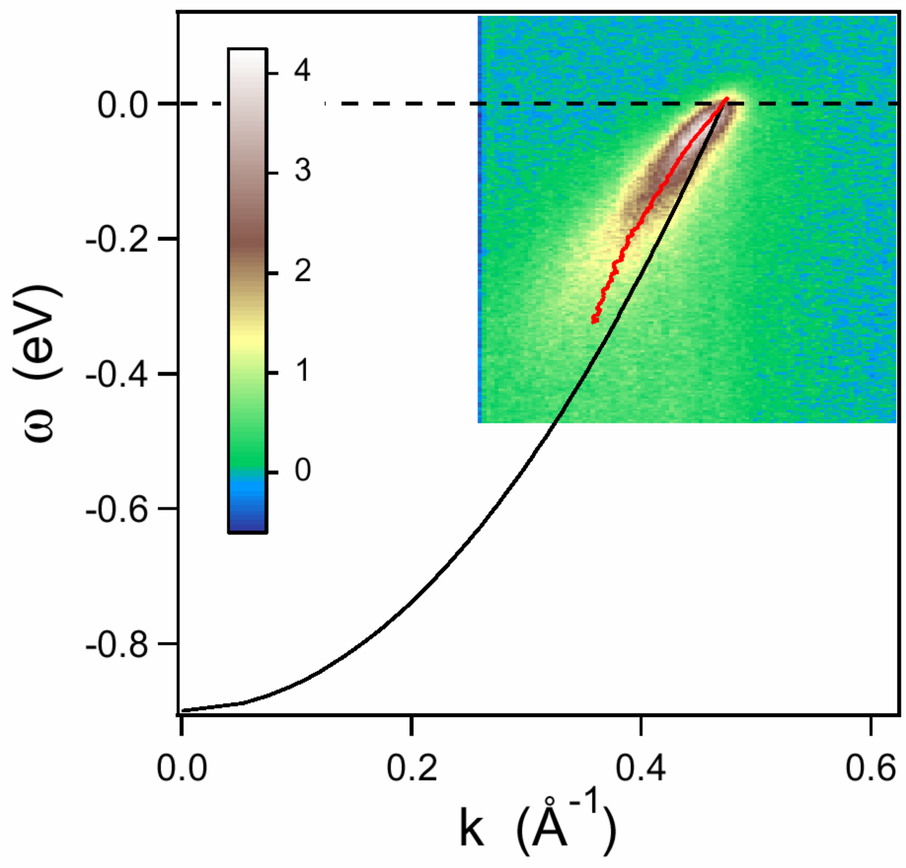
Real Self-Energy





$$v_F = 3.82 \pm 0.17\ \mathrm{eV\AA}$$

$$\lambda = 0.87 \pm 0.12$$

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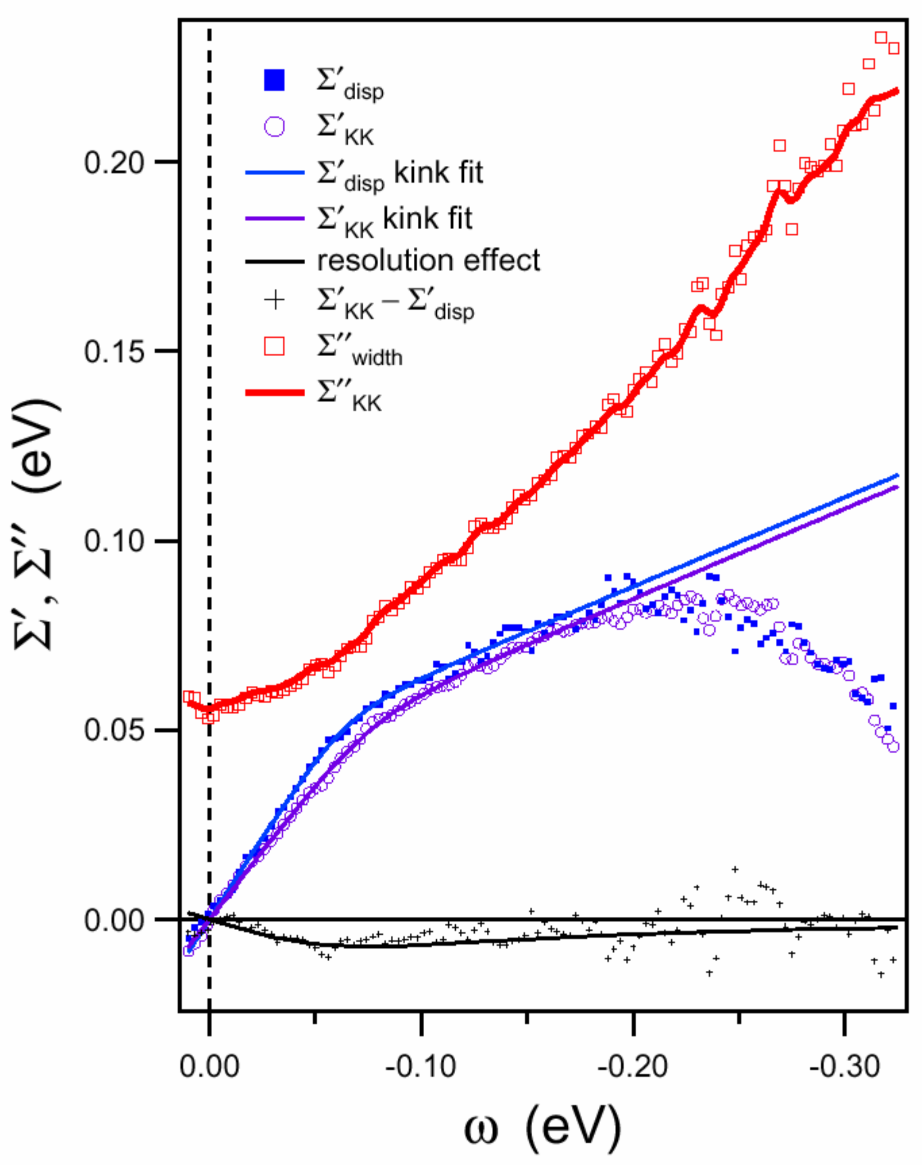
Real Self-Energy



Self-consistency:
LDA + self-energy

Well defined quasi-particles

Kink phenomenology

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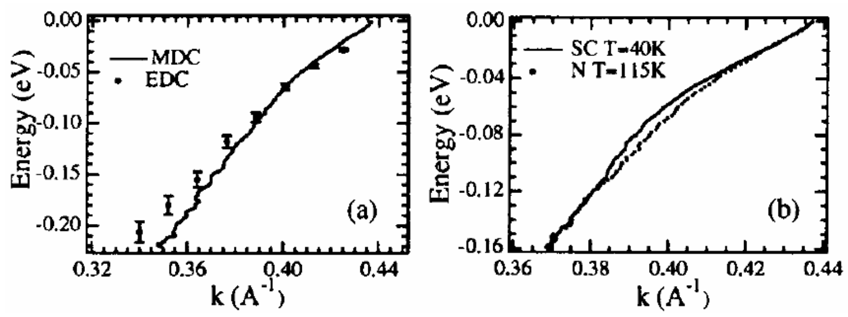
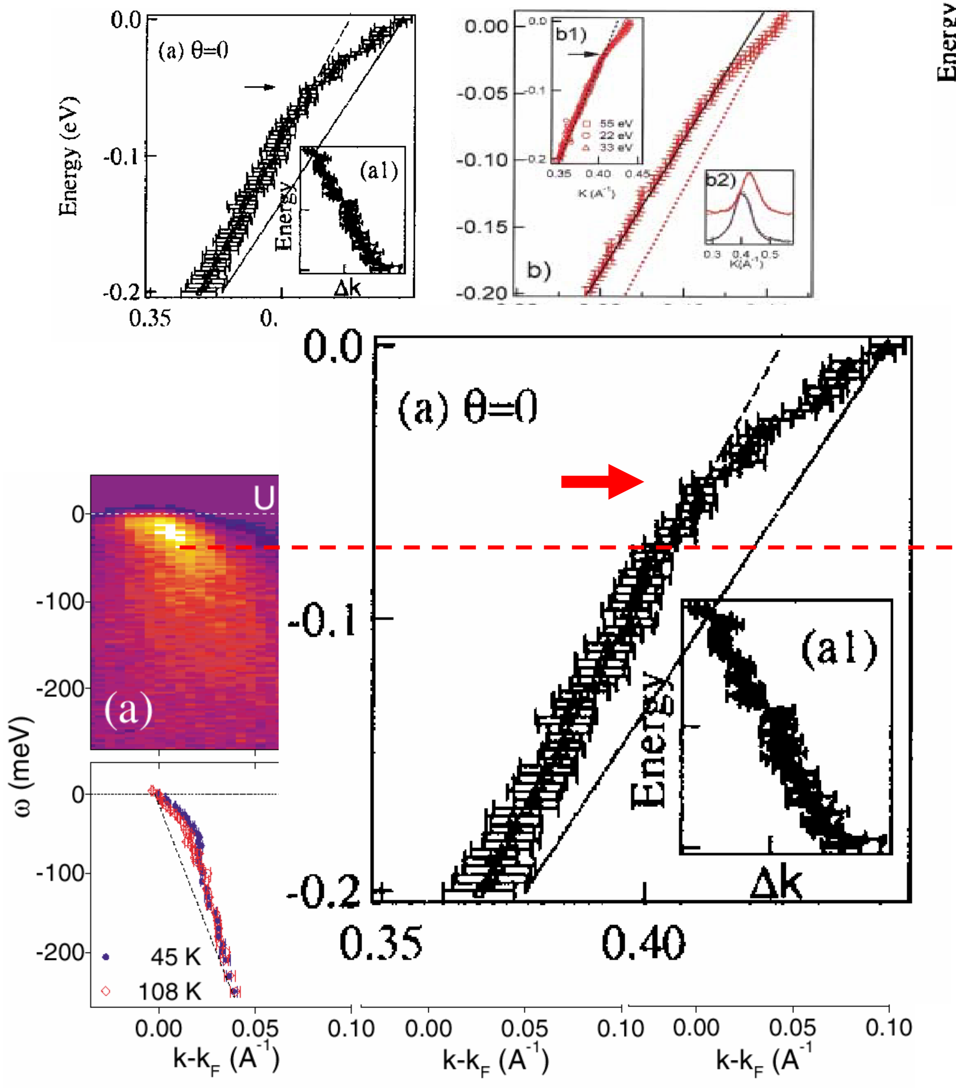
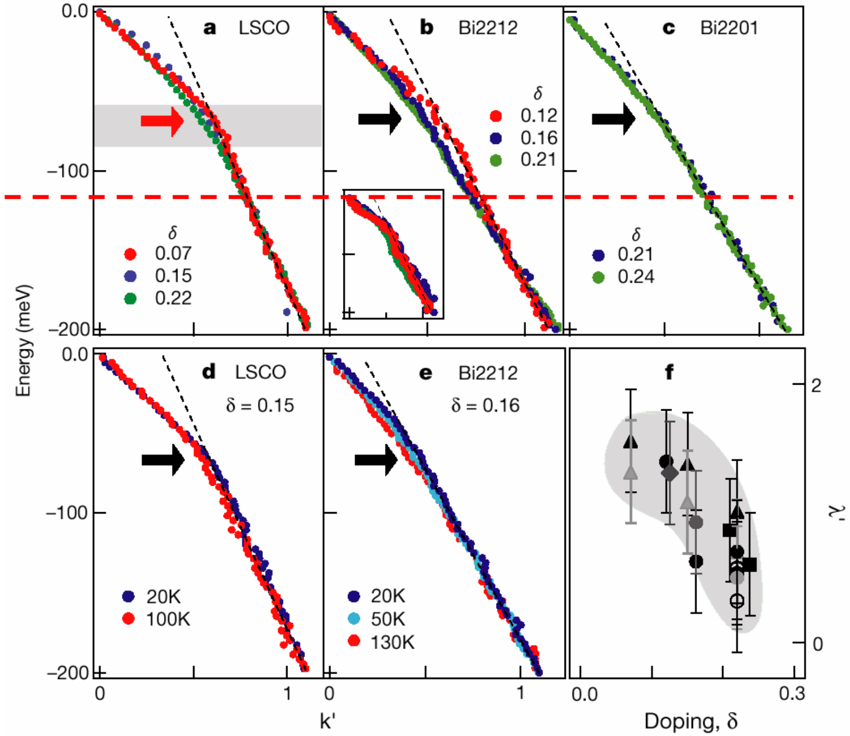
„Kinks“



Kaminski *PRL* 2001

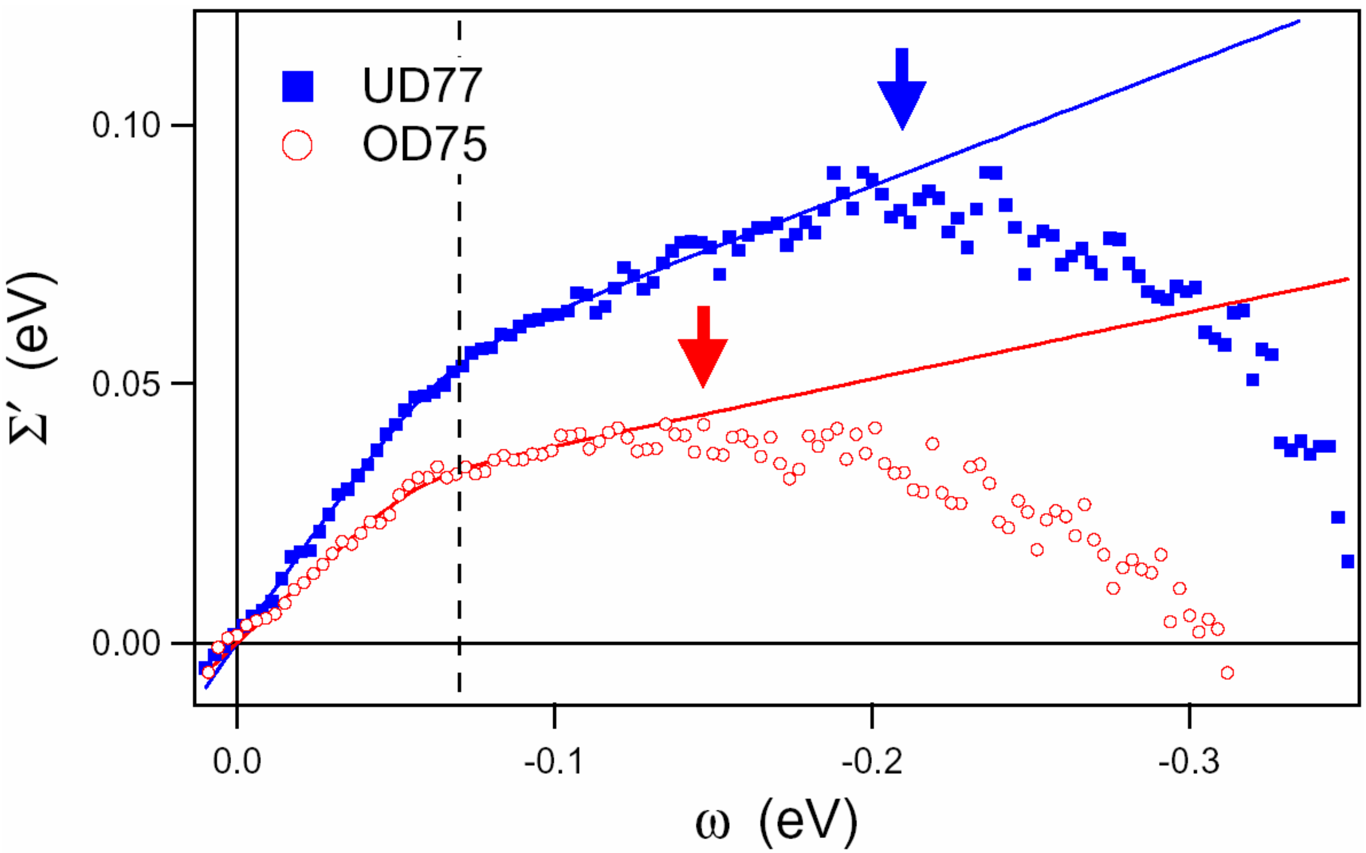


Johnson *PRL* 2001



Lanzara *Nature* 2001

Phenomenology of the kink

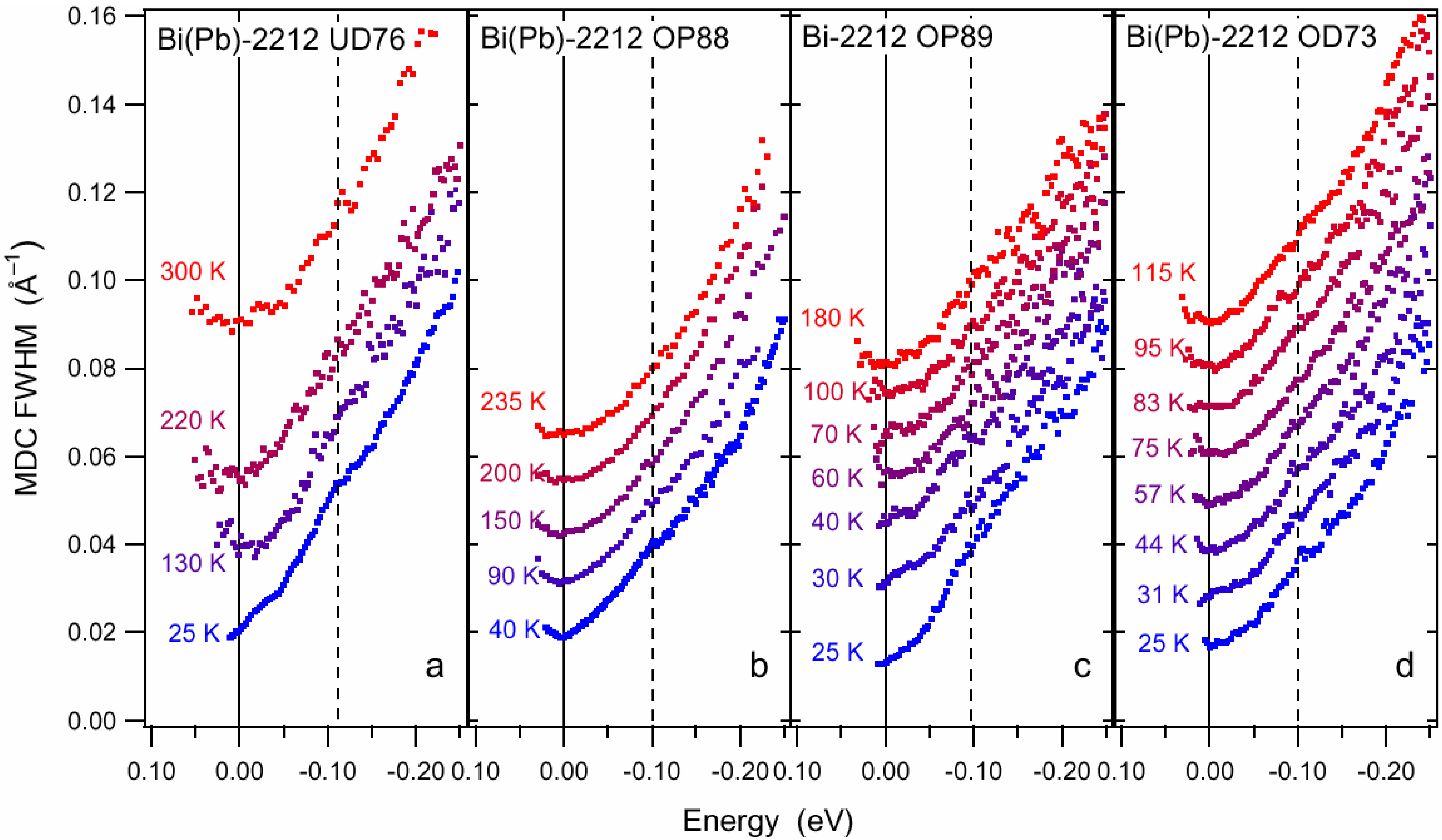


Kordyuk *PRB* 2005

Quasiparticle scattering rate

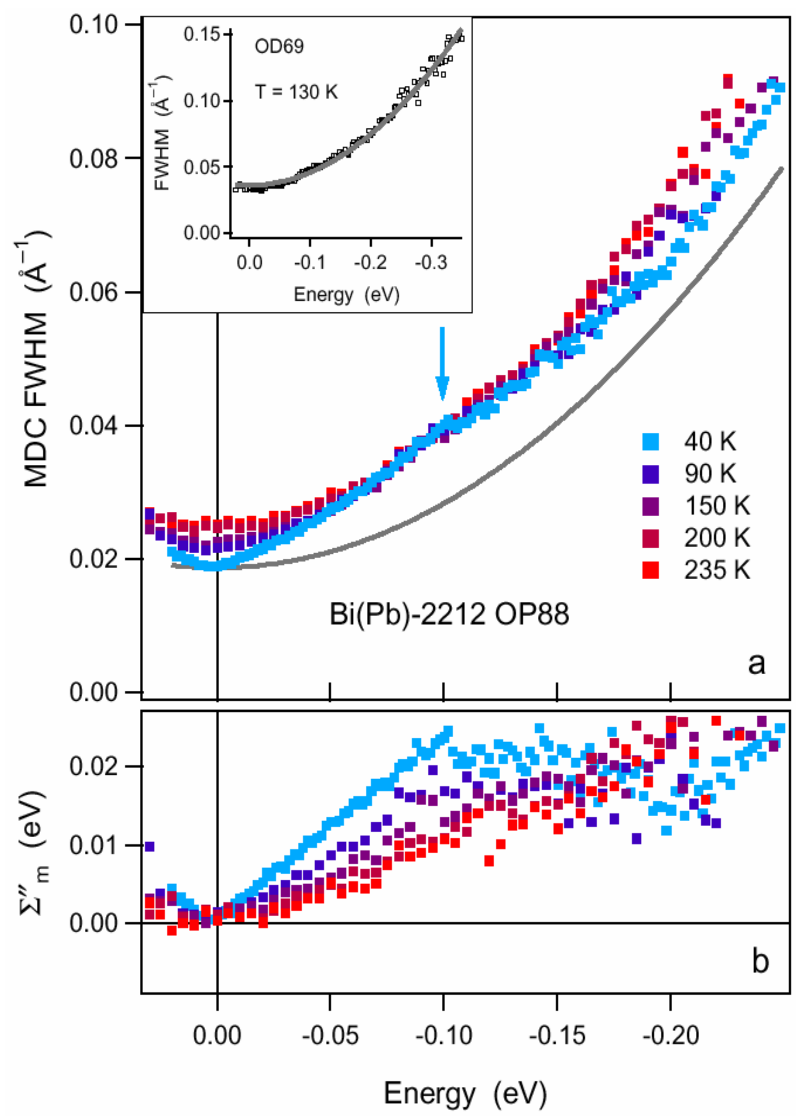
What is the main scatterer?

Scattering rate kink

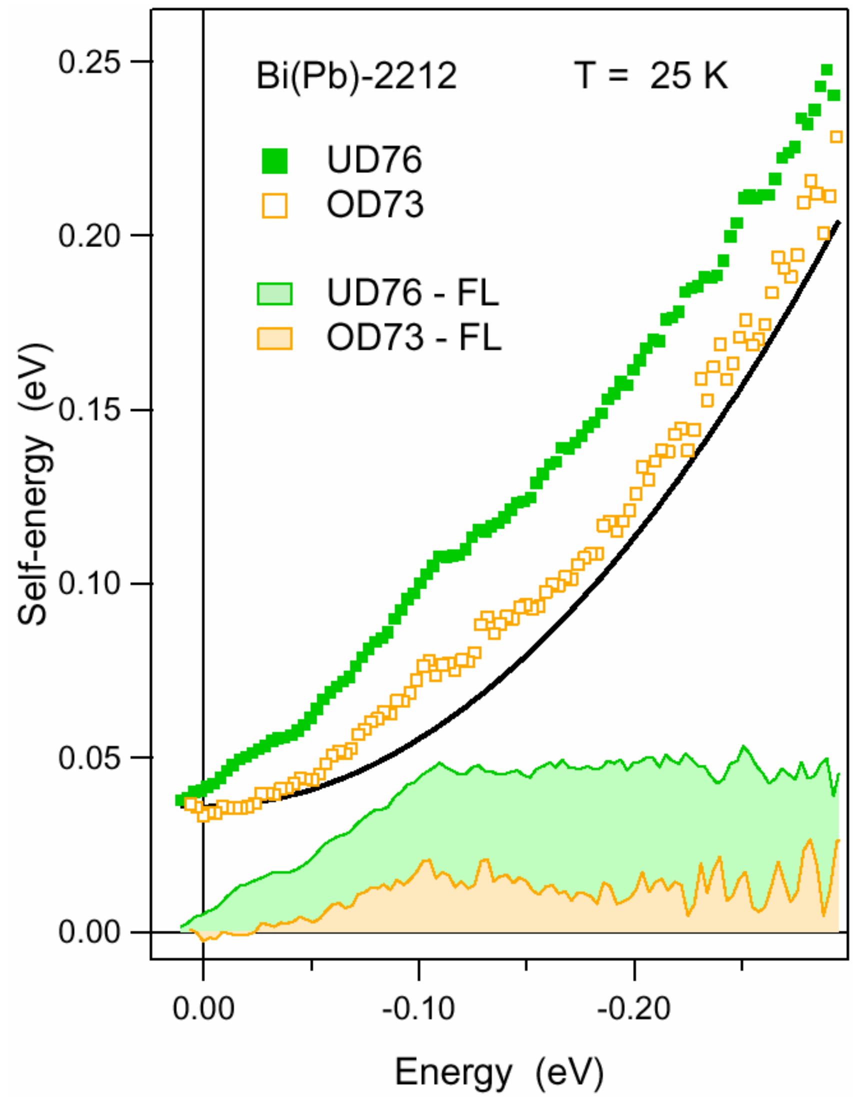


Kordyuk *PRL* 2004

Scattering rate: T-dependence

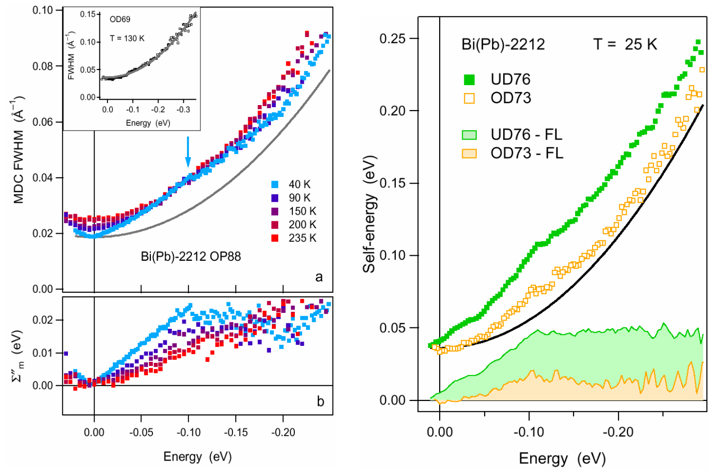


Doping dependence



Kordyuk *PRL* 2004

Scattering rate:
Some conclusions



There are two channels:

1st electron-electron scattering and

2nd electron-boson scattering